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Human Dental Remains from Gough's Cave (Somerset, England)

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Synopsis. The dental remains of nine individuals from Gough's Cave (Cheddar, Somerset) date from Late Pleistocene to the Holocene. Descriptions are provided for all individuals for crown and root morphology, odontometric data, dental pathology (caries, abscess, periodontal disease, enamel hypoplasia), calculus deposition, enamel pressure chipping, occlusal attrition, and evidence of intentional/occupational modification. The analytical focus is on seven individuals who date from the Late Upper Paleolithic/Mesolithic (Creswellian) culture periods. Comparative data from nine world populations suggest five trends: 1) Gough's Cave individuals have a morphologically simplified dental pattern similar to other Late Pleistocene/Early Holocene populations of North Europe, South/Southwest Asia and North Africa. 2) Within Europe, Gough's Cave is consistent in post-Pleistocene trend towards reduction in tooth size. 3) There is a temporal trend in the British Isles towards lateral incisor reduction, while maintaining stable molar tooth size. 4) Pathology, wear, and enamel pressure chipping are consistent with a hunter/gatherer lifeway, with one individual who may have occupationally related microtrauma. 5) No evidence occurs of any cleaning striations ('toothpick groves') as has been suggested for Neanderthals.

INTRODUCTION

Little is currently known about the dentition of Late Pleistocene/Early Holocene inhabitants of the British Isles. Excavations at Gough's Cave (Cheddar Gorge, Somerset) have recovered the dental remains for a minimum number of seven individuals dating to this time range. The remains have been radiocarbon dated to between 12,380 and 9,080 BP (Hedges *et al* 1991) and include 'Cheddar Man' (Gough's Cave 1), the most complete early human skeleton from Britain. Individuals from this time span date to the Upper Late Paleolithic/Mesolithic (Creswellian) culture periods. Dentition from two additional specimens (Gough's Cave 4 and 5) are more recent, dating to the Late Holocene. Gough's Cave 1, although dating to the Mesolithic time period, was included in analysis of the Upper Late Paleolithic group in order to maximize sample. While the sample is small the assumption is that the available data characterize individuals from early Gough's Cave.

The first part of this study describes all dental remains from Gough's Cave. Included are crown and root morphology, odontometric data, pathology (caries, abscess, periodontal disease, enamel hypoplasia), calculus deposition, enamel pressure chipping, occlusal attrition (wear), cultural treatment and intentional/occupational modification. The latter half of the study focuses specifically on the dentition from the Late Pleistocene/Early Holocene and provides a comparative analysis with other early and recent world populations.

General descriptions of the Gough's Cave skeletal and dental remains have been published elsewhere (Oakley *et al* 1971; Tratman 1975; Stringer 1985, 1990). This research is part of a larger series of forthcoming articles published in the Bulletin of the Natural History Museum that will present a detailed analysis of the material.

METHODS AND MATERIALS

Gough's Cave remains used in this study are currently housed at the Natural History Museum in London and were excavated in 1903, 1927–29, and 1986–87 (Davies 1904; Seligman & Parsons 1914; Keith & Cooper 1929; Cooper 1931; Currant *et al* 1989). Although Humphrey and Stringer (n.d.) argue for a numerically conservative approach, and suggest a minimum number of five individuals for the Late Pleistocene/Early Holocene group, the lack of any clear association between the dental elements (especially occlusion and enamel pressure chipping patterns) argues for a minimum number of seven individuals as presented in the current study (Table 1). The two more recent specimens (Gough's Cave 4 and 5) date to the Late Holocene.

Table 1 Gough's Cave specimen numbers, time period, age, sex, number of teeth with morphology data (includes root data and unerupted teeth), and number of teeth with odontometric data.

Specimen number	Time period	Age	Sex	Morphology (n = teeth)	Metrics (n = teeth)
87-25/87/49	Late Pleistocene	Adolescent	Unknown	27	18
87-103a	Late Pleistocene	Adult, mid-old	Unknown	1	1
87-139	Late Pleistocene	Adult, young-mid	Unknown	13	12
87-253	Late Pleistocene	Adult, young-mid	Male	10	5
89-001	Late Pleistocene	Adult, young	Unknown	1	1
Gough's Cave 6	Late Pleistocene	Adult, mid-old	Male	16	1
Gough's Cave 1	Early Holocene	Adult, young-mid	Male	27	20
Gough's Cave 4	Late Holocene	Adolescent	Unknown	6	1
Gough's Cave 5	Late Holocene	Adult, mid-old	Unknown	4	0
Total				105	59

The dental remains described here include three males (all Late Pleistocene/Early Holocene), with the remaining six of indeterminate sex. The Late Pleistocene/Early Holocene adults range in dental age from adolescent (n = 1), young adult (n = 1), young-middle adult (n = 3), middle-older adult (n = 2). The two Late Holocene individuals are an adolescent (Gough's Cave 4) and a middle-older age adult (Gough's Cave 5). Age determination for adolescents is based on eruption, degree of root formation, and occlusal wear. Adult age is based on degree of dental attrition, using the adolescent sample as a baseline.

Morphology: Crown and root morphology data for 105 teeth were collected using the Arizona State University Dental Anthropology System (Turner *et al* 1991). The Dental Anthropology System (DAS) consists of a series of rank-scaled reference plaques to score trait presence and degree of expression. When congenital absence of a tooth was suspected, the score was confirmed through use of radiographs. Data for two additional crown traits (to be added to DAS in the future) were collected: 1) maxillary premolar accessory ridge (Burnett *et al* 1996) and 2) upper premolar buccal style (Hawkey n.d.*a*).

For the purpose of analysis, the individual count was used (Turner & Scott 1977), a method that assumes the highest grade of expression for a given antimere best characterizes an individual's genotype for that trait. Thus, the score used for an individual is the highest grade observed between the two sides. In order to maximize sample size when only one side is present, the score for that side is used, and symmetry is assumed. Comparative key trait data for nine geographic populations were obtained from the literature and adjusted to reflect the DAS breakpoints for presence/absence following methodology used by Turner (1987). The key traits for a given tooth/feature are considered to be the most reliable population discriminators, and are scored for the teeth considered to be the least influenced by environmental factors according to the Field concept (Dahlberg 1945).

Metrics: Odontometric measurements for 59 teeth were taken using Helios needle-point calipers, calibrated to 0.05 mm. Each measurement was taken on three separate occasions and all were found to be within 0.05 mm difference. When discrepancies occurred, the results of the three measurements were averaged. The mesiodistal (MD) and buccolingual (BL) diameters of the maximum crown length and breadth were obtained, following the methods of Moorrees (1957). Teeth with observable interproximal wear were not measured for MD diameter. In addition, data for crown height of unworn teeth and complete root length were collected.

Asymmetry between right and left antimeres in both MD and BL diameters were assessed by paired samples t-test. A metric description of crown size and shape dimension was calculated by use of Crown Index, Crown Area, and Crown Module for all premolars and molars. Crown Index ([BL/MD] × 100) provides a measurement of relative crown breadth, with a score of 100 indicating that the BL and MD measurements are equal; a score greater than 100 denotes that the BL diameter is larger than the MD diameter. Crown Area (MDxBL) provides occlusal surface area, although it is assumed that the surface is rectangular. Crown Module ([MD+BL]/2) is calculated to indicate the average diameter of the tooth. While Crown Index provides some idea of occlusal shape, the Crown Module and Area describe the size of the crown. Incisor Breath (MD diameter I^2/MD diameter of I^1) was also determined because the MD ratio of the upper incisors has been proposed as useful in population affinity assessment (Lukacs 1985; Potter *et al* 1981).

When both sides were present, left side data were utilized for odontometric analysis. Due to the limited number of teeth available for analysis, right side measurements were used when the left side was absent (Goose 1963). Data from both sexes were pooled, because only three males could be identified reliably in the sample.

In order to characterize the population in a single figure, the Total Crown Area (sum of the mean crown area for all maxillary and mandibular teeth on one side) was calculated and presented as millimetres squared (mm^2). The Molar Crown Area for M1-M2 teeth (M1M2CA) was also calculated (sum of the Crown Area of maxillary and mandibular first and second molars on one side) in order to assess posterior tooth size. Ordinarily, the M3 is included in the calculation, but a lack of M3 data in the comparative samples necessitated use of only M1 and M2. The Penrose shape/size statistic (Penrose 1954) was used to assess dental metric population similarities based on both size and shape components; Corruccini (1973) has found the shape component to be particularly useful for population comparisons.

Pathology/occlusal attrition/crown chipping: Data for three forms of dental pathology (caries, abscessing, periodontal disease), calculus deposition and enamel hypoplasia were collected. Caries were scored for presence/location, following the definitions and procedures established by Koritzer (1977). An abscess was defined as a perforation of the alveolar bone connected to the root socket, while periodontal disease was noted in terms of degree of root exposure with antemortem erosion of the alveolar border (Turner *et al*, 1991). Calculus deposition was scored following Brothwell's (1981) definition of slight, medium, and heavy. Presence of enamel hypoplasia was scored as either chronic or acute episodes, in linear or pitting forms, with the dental age development estimate obtained from Schour and Massler's (1940) crown formation chart for U.S. Whites. Degree of occlusal attrition (wear) was noted for each tooth, following procedures established in DAS, with a score of '0' indicating no wear, '.5' as trace wear facets seen with 10x magnification, '1' has dentine exposed, '2' indicates cusps are worn away, '3' is exposed pulp, and '4' as functional root stump, with all or most of the enamel missing. Antemortem crown chipping (microtrauma) was determined through examination by a 10x hand lens to differentiate from post-mortem damage. Any presence of chipping was noted as to tooth and location on the tooth.

Other features: Any evidence of intentional dental modification (ablation, filing, inlay, staining), cleaning striations (brushing, interproximal 'toothpick' grooves), or occupational use of teeth were described.

SPECIMEN DESCRIPTIONS: LATE PLEISTOCENE/EARLY HOLOCENE

SPECIMEN. Gough's Cave 87-25/87/49 (including Specimens 009,120a, 120b, 165, 264b)

TIME PERIOD. Late Pleistocene (Late Upper Paleolithic)

DESCRIPTION. Individual is an older adolescent (approximately 15–18 years), based on eruption pattern and degree of occlusal wear. The specimen includes the left maxilla (87/25), right maxilla (87/87), and mandible (87/49), including the RI_1 (87/264b), LI_2 (87/102a), RP_3 (87/120b), LP_3 (87/165), and LP_4 (89/009). *Maxillary dentition:* Present are the $LRI^{1,2}$, LR^C, LP^3, retained deciduous lm^2, $LM^{1,2}$ and an unerupted LM^3. The RP^3, RP^4, $RM^{1,2,3}$ are missing postmortem and there is postmortem damage (chipping) on the occlusal edges of the $RI^{1,2}$ and the paracone of LM^2. *Mandibular dentition*: Teeth present are the RI_1, LI_2, LRP_3, LP_4, $LRM_{1,2}$, and unerupted

LRM_3. There is postmortem loss of the LI_1, RI_2, LR_C, and RP_4. There is no evidence of cultural treatment or modification of the teeth.

CROWN WEAR. All maxillary and mandibular anterior teeth present and all first molars exhibit slight to moderate (grade = 1) wear. All second molars have only wear facets present (grade = 0.5). All third molars are unerupted and lack wear.

ENAMEL PRESSURE CHIPPING. None occurs on either maxillary or mandibular teeth.

PATHOLOGY. No evidence occurs of caries, abscess, calculus, periodontal disease, or enamel hypoplasia on maxillary or mandibular teeth.

CROWN MORPHOLOGY. *Maxillary dentition:* LRI^1: labial curvature = 1, there is no winging. $LRI^{1,2}$: Absence of shovel, double shovel, interruption groove, tuberculum dentale. LRI^2 are not peg-shaped, or reduced. LR^C: lack shovel, double shovel, tuberculum dentale, mesial or distal accessory ridges. LP^3: lacks double shovel, accessory cusps, disto-sagittal ridge, enamel extension, odontome, MxPAR, or buccal style. LM^1: metacone = 4, hypocone = 5, lack of cusp 5. LM^2: metacone = 3.5, hypocone = 3, cusp 5 = 4 with the presence of cusp 6, (grade 1 on the UM5 plaque, with cusp 5 very much larger than cusp 6). Both molars lack Carabelli's trait, parastyle, and enamel extension. *Mandibular dentition:* RI_1 and LI_2: absence of shovel. LRP_3: lack enamel extension and odontome. RP_3: grade = 1 lingual cusp. LP_4: single lingual cusp (grade = 0). LRM_1: Y-5 pattern (cusp 5 = grade 5), protostylid = 1, enamel extension = 2, with absence of anterior fovea, cusp 7. LRM_2: + 5 pattern (cusp 5 = grade 3), with absence of deflecting wrinkle, distal and mid-trigonid crest, protostylid, cusp 7.

ROOT MORPHOLOGY. *Maxillary dentition*: LI^1: single root, with one radical. LI^2: single root with two radicals. L^C: single root with three radicals. LP^3: single root with two radicals. *Mandibular dentition*: All incisors, canines and premolars are single root teeth. RI_1: four radicals. LI_2: two radicals. RP_3: presence of Tomes' root (grade = 3), six radicals. LP_3: presence of Tomes' root, four radicals.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LI^1	9.28	7.85	–	12.20	–	–	–
RI^1	9.45	7.73	–	–	–	–	–
LI^2	7.38	7.23	–	12.95	–	–	–
RI^2	7.48	7.55	–	–	–	–	–
L^C	7.50	9.50	–	14.80	–	–	–
R^C	7.40	9.58	–	–	–	–	–
LP^3	6.43	9.28	–	10.00	144.32	59.67	7.86
LM^1	10.83	12.83	–	–	118.47	138.95	11.83
LM^2	10.23	13.23	–	–	129.33	135.34	11.73
dlm^2	9.48	11.50	–	–		–	–
RI_1	5.70	6.38	–	11.53			–
LI_2	6.23	7.03	–	13.48			–
LP_3	6.80	8.63	–	11.20	126.91	58.68	7.72
RP_3	6.78	8.90	–	11.18	131.27	60.34	7.84
LP_4	7.15	8.50	–	–	118.88	60.78	7.83
LM_1	11.58	11.15	–	–	96.29	129.12	11.37
RM_1	11.78	11.10	–	–	94.23	130.76	11.44
LM_2	11.90	10.43	–	–	87.65	124.12	11.17
RM_2	11.20	10.18	–	–	90.89	114.02	10.69

SPECIMEN. Gough's Cave 87-103a

TIME PERIOD. Late Pleistocene (Late Upper Paleolithic)

DESCRIPTION. An isolated LI^1 does not match any of the maxillary alveolar sockets present. There is perimortem damage to the distal third of the labial enamel surface. Occlusal wear and degree of root formation suggests the individual was middle-old age adult.

CROWN WEAR. Heavy wear occurs on the occlusal surface up to, but not exposing, the pulp chamber (grade = 3). An estimated loss of one-half of the total crown has occurred, with only the cervical one-half of the crown remaining.

ENAMEL PRESSURE CHIPPING. No evidence noted of antemortem chipping. Postmortem chipping occurs on the distal one-third of the labial crown surface.

PATHOLOGY. No carious activity is present in root or crown. No evidence occurs of enamel hypoplasia or calculus on the remaining cervical half of the crown.

CROWN MORPHOLOGY. Tooth is too worn to score for traits (labial curve, winging, shovel, double shovel, interruption groove, tuberculum dentale).

ROOT MORPHOLOGY. LI^1: single root, no radicals.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LI^1	–	6.98	–	6.30	–	–	–

SPECIMEN. Gough's Cave 87–139 [460-B-ALT; 301.0]

TIME PERIOD. Late Pleistocene (Late Upper Paleolithic)

DESCRIPTION. Specimen is of an adult maxilla, with complete alveolus and palate. Based on eruption and degree of occlusal wear, this individual is an adult, possibly young-middle age. Maxillary teeth present are the $LRI^{1,2}$, LR^C, LRP^3, RP^4, and $LRM^{1,2}$, with antemortem loss of LP^4. Postmortem damage occurred on the buccal surfaces of the LP^3, the LM^1 and LRM^2.The RM^3 is missing postmortem, and the LM^3 is congenitally absent. No evidence of cultural treatment or modification was found. Although Humphrey and Stringer (n.d.) suggest a possible association between this specimen and GC87–253, a lack of occlusion and lack of matching enamel pressure chipping patterns on the anterior dentition of GC87–253 argue against the two specimens representing a single individual.

CROWN WEAR. Slight-moderate, with heaviest wear on first molars (grade = 1.5), anterior teeth (grade = 1), and wear facets without dentine exposure (grade = 0.5) on the second molars.

ENAMEL PRESSURE CHIPPING. There is a minor degree of chipping on the disto-labial surfaces of LRI^1, the mesio-occlusal surfaces of LRI^2, and the buccal surface of L^C.

PATHOLOGY. Antemortem loss of LP^4 has occurred. No caries, abscessing, or calculus noted. Slight enamel hypoplastic pitting (acute episode) occurs near the CEJ on LI^2, LR^C, and RM^1. All remaining teeth do not display hypoplasia.

CROWN MORPHOLOGY. LRI^1: labial curvature = 1, tuberculum dentale = 1, absence of shovel, double shovel, interruption groove, and winging.; LRI^2: both teeth lack shovel, double shovel, interruption grooves, and are not peg/reduced shaped; RI^2 has tuberculum dentale = 2, (LI^2 is missing data) ; LR^C: absence of shovel, double shovel, tuberculum dentale, mesial accessory ridge; LRP^3: no double shovel on RP^3 (missing data for LP^3), lack of mesial/distal accessory cusps, disto-sagittal ridge, enamel extension, odontome, buccal style

on both teeth; RP^4: no accessory cusps, enamel extension, odontome, buccal style; RM^1: metacone = 4, hypocone = 4, absence of cusp 5, Carabelli's trait, parastyle, enamel extension; LM^1: hypocone = 4, lack of Carabelli's trait, enamel extension; RM^2: enamel extension = 1, absence of hypocone, cusp 5, Carabelli's trait; LM^2: metacone = 4, hypocone = 1, absence of cusp 5, Carabelli's trait.

ROOT MORPHOLOGY. Could not be determined.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LI^1	9.60	7.45	–	–	–	–	–
RI^1	9.90	7.33	–	–	–	–	–
LI^2	8.20	7.90	–	–	–	–	–
RI^2	7.85	7.28	–	–	–	–	–
L^C	8.13	9.85	–	–	–	–	–
R^C	7.95	9.98	–	–	–	–	–
LP^3	6.73	9.03	–	–	134.17	60.77	7.88
RP^3	6.03	–	–	–	–	–	–
RP^4	5.75	8.83	–	–	–	–	–
LM^1	–	12.20	–	–	–	–	–
RM^1	10.28	–	–	–	–	–	–
LM^2	9.75	–	–	–	–	–	–

SPECIMEN. Gough's Cave 87–253 [304.0]

TIME PERIOD. Late Pleistocene (Late Upper Paleolithic)

DESCRIPTION. Mandibular fragment of an adult male, consisting mainly of the right portion of the mandible, separated just distal to LI_2, and including the lower portion of the right ramus. There is postmortem loss of LRI_1,RI_2, RP_3. The RM_3 is congenitally absent. Mandibular teeth present are the LI_2 (89/003) R_C (87/263), RP_4 (89/002), and $RM_{1,2}$. There is no evidence of cultural treatment or modification. On the basis of occlusal wear and calculus deposition, this adult is estimated to be young-middle age.

CROWN WEAR. Slight-moderate, with heaviest wear (grade = 1.5) on the first molar and anterior teeth (grade = 1), and second molars with wear faceting, but no dentine exposure (grade = 0.5).

ENAMEL PRESSURE CHIPPING. None.

PATHOLOGY. No caries, abscessing, or periodontal disease occur. There is possible pitting on the buccal surface near CEJ on the R_C. A slight degree of calculus is present at the CEJ of all teeth.

CROWN MORPHOLOGY. LI_2: absence of shovel; RP_4:single lingual cusp (grade = 0), absence of odontomes, absence of buccal style; RM_1: Y-5 pattern (cusp 5 = grade 4), enamel extension present (grade = 2), absence of protostylid, cusp 7; RM_2: X-4 pattern, enamel extension present (grade = 3), absence of deflecting wrinkle, distal trigonid crest, mid-trigonid crest, protostylid, cusp 7.

ROOT MORPHOLOGY. All incisors, canines and premolars are single-rooted; LI_2: radicals = 2 ; R_C: radicals = 2; RP_4: radicals = 1.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LI_2	5.15	6.50	–	–	–	–	–
R_c	7.68	8.70	–	–	–	–	–
RP_4	6.58	8.33	6.08	13.53	126.60	54.81	7.46
RM_1	10.08	10.45	–	–	103.67	105.34	10.33
RM_2	10.15	10.58	–	–	104.24	107.39	10.37

SPECIMEN. Gough's Cave 89–001 [Area I/M102/701.0]

TIME PERIOD. Late Pleistocene (Late Upper Paleolithic)

DESCRIPTION. An isolated tooth, LP_4, that does not belong to the same individual as Gough's Cave 89–002 or 89–003, on the basis of morphology, metrics or degree of wear. Amount of occlusal wear and degree of root formation suggest a young adult.

CROWN WEAR. Slight wear facets (grade = 0.5) are on the buccal/occlusal surface, although no dentine is exposed.

ENAMEL PRESSURE CHIPPING. None.

PATHOLOGY. No caries or enamel hypoplasia, but a slight degree of calculus is present on the buccal and lingual surfaces of the cervical fourth of the crown.

CROWN MORPHOLOGY. Single lingual cusp (grade = 0), trace of buccal style (both mesial and distal), no odontome.

ROOT MORPHOLOGY. Single rooted, with three radicals.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LP_4	7.10	8.25	–	6.93	116.20	58.58	7.68

SPECIMEN. Gough's Cave #6

TIME PERIOD. Late Pleistocene: 11,700 ± 100 BP [OxA-2236] (Late Upper Paleolithic)

DESCRIPTION. An almost complete mandible (missing right ramus) of an adult male. Only the RM_2 is present. There is postmortem loss of $LRI_{1,2}$, LR_C, $LRP_{3,4}$, LRM_1, and LM_2. Both LRM_3 are congenitally absent. There is no evidence of cultural treatment or modification on the remaining tooth. The individual appears to be middle-old age on the basis of occlusal wear and amount of root exposure.

CROWN WEAR. Moderate wear (grade = 2) of dentine exposure on RM_2.

ENAMEL PRESSURE CHIPPING. None.

PATHOLOGY. No evidence for abscessing occurs. No caries, calculus, enamel hypoplasia present on remaining tooth, although there is a slight degree (1–2 mm) of root exposure.

CROWN MORPHOLOGY. RM_2: 4-cusped, lacking a protostylid, cusp 7.

ROOT MORPHOLOGY. All incisors, canines and premolars are single-rooted. Both first molars are two-rooted, although the root sockets of RM_1 indicate that the mesial root is slightly bifurcated (approximately a fourth of the total root length). The RM_2 is three-rooted and the socket for LM_2 has a mesial and distal root socket with a small auxiliary lingual root socket positioned just distal to the mesial alveolar socket, suggesting a 3-rooted tooth.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
RM_2	12.03	10.90	–	–	90.61	131.13	11.47

SPECIMEN. Gough's Cave #1 ['Cheddar Man']

TIME PERIOD. Early Holocene: 9,080 ±150 BP [BM-525]; 9,100 ± 100 BP [OxA-814] (Mesolithic/Creswellian)

DESCRIPTION. Adult male with an almost complete mandible (missing left coronoid process and the left and right condyle) and an almost complete maxilla (missing the palate). *Maxillary teeth:* Present are the $LRM^{1,2,3}$ with postmortem loss of $RI^{1,2}$, R^C, RP^3, LRP^4. The remainder of the teeth ($LI^{1,2}$, L^C, LP^3) were damaged postmortem and observations were not made. *Mandibular teeth:* The $LRI_{1,2}$, LR_C, $LP_{3,4}$, and $LRM_{1,2,3}$ are present. Postmortem loss of $RP_{3,4}$ had occurred. There was no evidence of any cultural treatment or modification of the teeth. On the basis of eruption and occlusal wear, the individual was of young-middle age.

CROWN WEAR. Moderate to slight, with heaviest wear on LP_4, and RM_1 (grade = 1.5), remaining anterior teeth and LM_1 (grade = 1), and all remaining molars (grade = 0.5).

ENAMEL PRESSURE CHIPPING. RM^1: lingual portion of the hypocone.

PATHOLOGY. No evidence occurs of caries, abscessing, periodontal disease, enamel hypoplasia, or calculus.

CROWN MORPHOLOGY. *Maxillary teeth*: LRM^1: metacone = grade 4, hypocone = grade 4, absence of cusp 5, Carabelli's trait, parastyle, and enamel extension. RM^2: metacone = 4, hypocone = 3, cusp 5 = 3, with lack of Carabelli's trait, parastyle, enamel extension. LM^2: metacone = 4, hypocone = 1, with absence of cusp 5, Carabelli's trait, parastyle, and enamel extension. LRM^3: metacone = 3.5, hypocone = 1, with absence of cusp 5, Carabelli's trait, parastyle, enamel extension. Neither third molar exhibited a peg or reduced form. *Mandibular teeth:* All incisors lacked shovel. L_C: absence of distal accessory ridge. LP_3: lacked a lingual cusp (grade = A), and both $LP_{3,4}$ did not have enamel extension, or odontomes. LRM_1: have the Y-5 pattern (cusp 5 grade = 5), and lack protostylid, cusp 7, and enamel extension. LRM_2 and LM_3:have an X-4 pattern, with absence of deflecting wrinkle, distal and mid-trigonid crests, protostylid, cusp 7, and enamel extension. RM_3: has a Y-4 pattern and also lacks deflecting wrinkle, distal and mid-trigonid crest, protostylid, cusp 7. Because molars are slightly crowded, the torso-molar angle could not be assessed.

ROOT MORPHOLOGY. $RP_{3,4}$: single-rooted.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LM^1	10.80	11.53	–	–	106.76	124.52	11.17
RM^1	10.95	11.55	–	–	105.48	126.47	11.25
LM^2	10.00	11.68	7.18	–	116.80	116.80	10.84
RM^2	10.95	11.75	7.58	–	107.31	128.66	11.35
LM^3	8.33	11.13	7.50	–	133.61	92.71	9.73
RM^3	9.20	11.38	7.88	–	123.70	104.70	10.29
LI_1	4.65	5.60	–	–	–	–	–
RI_1	4.93	5.55	–	–	–	–	–
LI_2	5.15	6.08	–	–	–	–	–
RI_2	5.25	5.93	–	–	–	–	–
L_C	6.05	7.63	–	–	–	–	–
R_C	6.48	7.50	–	–	–	–	–
LP_3	6.40	7.33	–	–	114.53	46.91	6.87
LP_4	6.83	7.98	–	–	116.84	54.50	7.41
LM_1	11.03	10.28	–	–	93.20	113.39	10.66
RM_1	11.18	10.33	–	–	92.40	115.49	10.76
LM_2	10.03	9.80	8.13	–	97.71	98.29	9.92
RM_2	10.03	10.08	7.20	–	100.50	101.10	10.06
LM_3	10.68	10.00	8.18	–	93.63	106.80	10.34
RM_3	10.83	10.03	–	–	92.61	108.62	10.43

SPECIMEN DESCRIPTIONS: LATE HOLOCENE

SPECIMEN. Gough's Cave #4 [Cooper 1929 No. 7]

TIME PERIOD. Late Holocene

DESCRIPTION. Maxillary fragment separated along mid-line of a young-late adolescent individual. Age category was made on the basis of dental eruption, root formation and occlusal wear. The LM^1 is present, and the crown of the LM^3 is complete although unerupted, with the roots not yet formed. Postmortem loss occurred of $LI^{1,2}$, L^C, $LP^{3,4}$, LM^2.Alveolar sockets indicate the roots of $LP^{3,4}$ are completely formed, while the roots for LM^2 have not completely formed. There is no indication of cultural modification or treatment of the teeth.

CROWN WEAR. The LM^1 has slight wear faceting with no dentine exposure (grade = 0.5).

ENAMEL PRESSURE CHIPPING. None.

PATHOLOGY. No caries, abscessing, periodontal disease, or enamel hypoplasia present, although there is slight-moderate formation of calculus on the buccal surface near CEJ.

CROWN MORPHOLOGY. LM^1: metacone = 4, hypocone = 3.5, Carabelli's trait = 2, absence of cusp 5, and enamel extension. There is a very faint parastyle expression, although it is not the buccal pit form (grade 1) and the expression of the trait is too weak to classify it as grade 2, because it lacks a free apex.

ROOT MORPHOLOGY. $LI^{1,2}$, L^C, $LP^{3,4}$: single-rooted teeth.

ODONTOMETRIC DATA

	crown dimensions MD	BL	crown height	root length	crown index	crown area	crown module
LM^1	10.10	9.88	5.85	–	97.82	99.79	9.99

SPECIMEN. Gough's Cave #5 [Cooper 1929]

TIME PERIOD. Late Holocene

DESCRIPTION. Right mandibular fragment of an adult, with postmortem loss of R_C, $RP_{3,4}$, RM_2. The RM_1 is present. Degree of occlusal wear suggests middle-old age.

CROWN WEAR. The RM_1 is heavily worn, with the pulp chamber almost exposed (grade = 2.5).

ENAMEL PRESSURE CHIPPING. RM_1:buccal and mesio-buccal surfaces.

PATHOLOGY. No caries, abscessing, periodontal disease, or enamel hypoplasia, although a slight-moderate degree of calculus is present.

CROWN MORPHOLOGY. RM_1:absence of enamel extension.

ROOT MORPHOLOGY. R_C, $RP_{3,4}$: single-rooted teeth.

ODONTOMETRIC DATA. None available due to wear.

Table 2 Number of Gough's Cave individuals (Late Pleistocene/Early Holocene) with any morphological expression for a given trait.

Data are presented only for grades that were present in the sample. Traits lacking any morphological expression in the sample are winging (UI1), labial curvature (UI1), shovel (UI1-2, UC, LI1-2), double-shovel (UI1-2, UC, UP3), interruption groove (UI1-2), canine mesial accessory ridge (UC), canine distal accessory ridge (UC, LC), premolar distal accessory cusps (UP3-4), maxillary premolar accessory ridge (UP3 only), premolar buccal style (UP3-4), disto-sagittal ridge (UP3), odontomes (UP3-4, LP3-4), Carabelli's trait (UM1-2-3), parastyle (UM1-2-3), anterior fovea (UM1), deflecting wrinkle (LM2-3 only), distal trigonid crest (LM2-3 only), cusp 6 (LM1-2-3), cusp 7 (LM1-2-3), mid-trigonid crest (LM2-3 only).

All upper and lower incisors, canines and premolars are single-rooted. The only data available for molars are from a single individual who has both lower M1 (two-rooted) and a lower M2 (three-rooted).

Tuberculum Dentale

grade	UI1	UI2	UC
0	1	1	2
1	1	0	0
2	0	1	2
Total	2	2	4

Metacone

grade	UM1	UM2	UM3
3.5	0	1	1
4	3	2	0
Total	3	3	1

Upper Molar Cusp 5

grade	UM1	UM2	UM3
0	3	1	1
3	0	1	0
4	0	1	0
Total	3	3	1

Hypocone

grade	UM1	UM2	UM3
1	0	1	1
3	0	2	0
4	2	0	0
5	1	0	0
Total	3	3	1

Enamel Extension

grade	UP3	UP4	UM1	UM2	UM3
0	2	1	3	2	1
1	0	0	0	1	0
Total	2	1	3	3	1

Peg, Reduced, Congenital Absence

grade	UI2	UP4	UM3	LI1	LP4	LM3
+	3	2	2	5	6	2
-	0	0	1	0	0	1
Total	3	2	3	5	6	3

Lower Molar Cusp Pattern

grade	LM1	LM2	LM3
Y	3	0	1
X	0	2	0
+	0	1	0
Total	3	3	1

Premolar Lingual Cusp

grade	LP3	LP4
0	0	2
A	1	0
1	1	0
Total	2	2

Lower Molar Cusp Number

grade	LM1	LM2	LM3
4	0	3	1
5	3	1	0
Total	3	4	1

Lower Molar Cusp 5

grade	LM1	LM2	LM3
4	0	3	1
5	3	1	0
Total	3	4	1

Protostylid

grade	LM1	LM2	LM3
0	2	4	1
1	1	0	0
Total	3	4	1

Tomes' Root

grade	LP3
0	1
3	1
Total	2

RESULTS: LATE PLEISTOCENE/EARLY HOLOCENE REMAINS

Morphology: Grades for teeth with a given trait (number or individuals = 7, number of teeth = 97) are summarized in Table 2, and include root number data obtained from the alveolar socket when postmortem loss of a tooth occurred. In general, Gough's Cave individuals have a simplified, modern *Homo sapiens* dental pattern, and lack strong expression for almost all traits.

Presence/absence breakpoints for key tooth/trait combinations limit the sample available for analysis due to use of the individual count (number of key trait observations = 65). There is a lack of winging (0/2), shovel I^1 (0/2), double shovel I^1 (0/2), interruption groove I^2 (0/2), upper canine mesial accessory ridge, or 'Bushman's canine' (0/2), upper canine distal accessory ridge (0/1), disto-sagittal ridge or 'Uto-Aztecan premolar' P^3 (0/2), Carabelli's trait M^1 (0/3), cusp 5 M^1 (0/3), parastyle M^3 (0/1), enamel extension M^1 (0/4), greater than one lingual cusp P_4 (0/2), Y-groove M_2 (0/3), cusp 6 M_1 (0/3), cusp 7 M_1 (0/3), two-rooted lower canine (0/4), three-rooted lower molar (0/1), one-rooted M_2 (0/1), or upper/lower premolar odontomes (0/5). There are some instances of presence of tuberculum dentale I^2 (1/2), peg/reduced/congenital absence of M^3 (1/3), protostylid M^1 (1/3), Tomes' root P_3 (1/2). Higher frequencies were noted for presence of one-rooted P^3 (2/2), presence of hypocone M^2 (2/3) and four-cusped M_2 (3/4).

Metrics: Out of 58 teeth measured in the Late Pleistocene/Early Holocene sample, a total of 16 permanent maxillary teeth and 21 permanent mandibular teeth supplied data for the seven individuals, with the means summarized in Table 3. Fluctuating dental asymmetry in tooth size is present in the sample, although the results from paired t-tests between antimeres do not indicate significant differences statistically ($p = 0.05$). Only one individual (Gough's Cave 6) had all maxillary or mandibular molar teeth present. Crown Area in Gough's Cave 6 indicates an upper molar decrease from $M^1 > M^2 > M^3$. Lower molars follow a slightly different pattern of $M_1 > M_2 < M_3$.

The TCA for the Gough's Cave sample is 1,244 mm^2 (I1-M3) and 1,034 mm^2 (I1-M2), while the M1M2CA is 486 mm^2. There is a lack of reduction in lateral incisor MD diameters when compared to the MD measurement for the central incisors, with the incisor breadth (I^1: I^2) ratio of 0.83.

Pathology/occlusal attrition/crown chipping: All seven individuals could be assessed for pathology, although of these, three were represented by isolated teeth. There is an apparent lack of caries and abscessing in this series. Antemortem tooth loss (LP^4) occurred in only one individual (87/139). This same young adult also has the only instance of macroscopically observable enamel hypoplasia, an acute episode with pitting which occurs at the cemento-enamel junction (CEJ) of three teeth (I^1, ^{C}, M^1) during crown formation between three to five years of age. Although no periodontal pockets occur, one adult male (Gough's Cave 6) showed evidence of 1–2 mm of root exposure of M_2, the only tooth remaining, the rest having been lost postmortem. There does seem to be higher degree of calculus deposition (slight grades: confined to crown but not extending to the CEJ) occurring in two young-middle age adults (87-253, 89–001), including only one of the three identifiable males in the sample.

The degree of attrition in the sample is similar to other hunter/gatherer groups, in that the rate of wear is not excessive (i.e., the pulp chamber is not exposed before secondary dentine is formed to protect tooth integrity). Thus, the majority of wear seems likely to be age-related rather than occupational or due to highly abrasive diet. In

Table 3 Summarized odontometric data for Gough's Cave sample (Late Pleistocene/Early Holocene), including number of individuals (n), mean mesio-distal diameter (MD), mean bucco-lingual diameter (BL), standard deviation (sd) and mean crown area. Data are for the left side, with right side substituted when the left is missing. When only one tooth is available, data are presented in parentheses.

Tooth	n	Avg. MD	sd	n	Avg. BL	sd	Crown Area
UI1	2	9.44	0.23	3	7.43	0.44	70.14
UI2	2	7.79	0.58	2	7.57	0.47	58.97
UC	2	7.82	0.45	2	9.68	0.25	75.70
UP3	2	6.58	0.21	2	9.16	0.17	60.27
UP4	1	(5.75)	–	1	(8.83)	–	(50.77)
UM1	3	10.64	0.31	3	12.19	0.65	129.70
UM2	3	9.99	0.24	2	12.46	1.10	124.48
UM3	1	(8.33)	–	1	(11.13)	–	92.71
LI1	2	5.18	0.74	2	5.99	0.55	31.03
LI2	3	5.51	0.62	3	6.54	0.48	36.04
LC	2	6.87	1.15	2	8.10	0.85	55.65
LP3	2	6.60	0.28	2	7.98	0.92	52.67
LP4	4	6.92	0.26	4	8.27	0.22	57.23
LM1	3	10.90	0.76	3	10.64	0.44	115.98
LM2	4	11.03	1.09	4	10.50	0.34	115.82
LM3	1	(10.68)	–	1	(10.93)	–	(116.73)

adults, the wear on the anterior teeth is almost always grade 1 (some dentine exposed). There is one instance of an isolated upper incisor (87-103a) that is heavily worn (grade 3) although probably due to age-related wear consistent with older age. The maxillary first molars have a wear range of grades 1–1.5, with the lower molars experiencing slightly more wear (grades 1–2.5), although again, the type of wear suggests older adults. All erupted maxillary and mandibular second and third molars in the sample were only slightly worn (grade = 0.5).

The degree of wear may be correlated with instance of molar crown pressure chipping in at least one individual. In Gough's Cave 1, the RM^1, has an attrition score of grade 1, although the tooth exhibits chipping along the lingual surface of the hypocone; its antimere, LM^1, has the same amount of wear but lacks any evidence of pressure chipping. However, the mandibular counterparts to these two teeth indicate much heavier use of the right side, with the RM_1 wear grade of 1.5, (no chipping) while the LM_1 mirrors the lesser wear (no chipping) of the left maxillary molar. Two other individuals (87-253, Gough's Cave 6), have a high degree of attrition on the lower molars, but wear is not correlated with pressure chipping.

Specimen 87-139, a young-middle age adult, displays an attrition/chipping pattern that may be consistent with occupational use of the teeth. Crown microtrauma occurs on the maxillary incisors, between the right $I^{1,2}$, and the left $I^{1,2}$, and on the buccal surface of the left upper canine. The LP^4 was lost antemortem, and the LP^3 crown was damaged postmortem. The left side of the anterior dentition may have been utilized more in this adult; the R^C, $RP^{3,4}$, and $LRM^{1,2}$ did not display evidence of chipping. Because there are no instances of caries in the sample, the antemortem loss of LP^4 may be related to the degree and amount of pressure chipping found in the dentition of this specimen. Unfortunately, no mandibular dental remains for this adult were recovered.

Other Features: There is no evidence of cultural treatment (i.e., interproximal 'toothpick' grooves, enamel cleaning striations) or of intentional dental modification.

COMPARATIVE ANALYSIS

Results of this comparative analysis are based on a numerically limited series should be treated with caution. The analysis presented here suggests only possible trends present in the available data, and with the assumption that these few individuals from Gough's Cave are representative of the populations of the Late Pleistocene/Early Holocene British Isles.

Morphology: Table 4 presents a comparison of the Gough's Cave morphological data with the occurrence of 20 key traits in seven early populations: Upper Paleolithic-Neolithic North Europe (*ca.*32,000–4,000 BP), Mesolithic Nubia (*ca.* 18,000–12,000 BP), Iberomaurusian North Africa (*ca.* 16,700–10,500 BP), Epi–Paleolithic Levant Natufians (*ca.* 12,800–10,200 BP), Mesolithic–Neolithic South Asia (*ca.* 8,000 –2,800 BP), Neolithic-Bronze Age Lake Baikal (*ca.* 7,400–3,800 BP), and Jomon Japan (*ca.* 7,000–2,300 BP). The data are also compared with two historic pooled populations: North Europe, and Khoisan-speakers of sub-Saharan Africa. Results were compared with the Early World Average for each trait (Hawkey 1998) . Populations were then designated as having percentages higher than (H), lower than (L) or within five percent above or below the Early World Average (A). Because the Gough's Cave sample is so small numerically, the frequency of each trait is characterized as having total absence (0), less than or equal to 50 percent (+), or more than half the sample (++).

Among world populations, the Gough's Cave dental morphology seems most like other early world groups with a simplified dental pattern. Gough's Cave is most similar to Late Pleistocene/Late Holocene (Neolithic) North Europe, sharing trait frequencies of 83.3%. By historic times, Gough's Cave is still like Recent North Europe (72.2%), although there are differences in presence of tuberculum dentale, hypocone, Carabelli's trait, one-root P^3 , and cusp 7. The simplified dental pattern seen in Gough's Cave shares similarities with two other Late Pleistocene/Early Holocene world samples: Epi-Paleolithic Levant Natufians (70.0%) and North African Iberomaurusians (70.0%), and with the Early Holocene sites of South Asia (83.3 %) and Jomon (80.0%).

The sample is dentally unlike the Late Pleistocene sites of Nubia (42.1%), and the Late Holocene (Neolithic-Bronze Age) inhabitants of Lake Baikal (52.6%). If the Khoisan-speaking populations from modern sub-Saharan Africa are taken to represent the early sub-Saharan African dental pattern (Irish 1993, 1998), then Gough's Cave shares only 60% of key traits with this geographic group.

Only one archaic dental trait appears in the sample. Presence of P_3 Tomes' root occurred in one out of two individuals who could be scored for the trait. A study of more than 7,700 individuals (Turner & Hawkey 1991) found that the trait occurs most often in Africa, ranging from 20–50%, with the Late Pleistocene Nubian sample among the highest in the world (47%). North Europe averages 9%of trait presence, although the range can be quite broad (0–43%). The instance of Tomes' root in this sample, therefore, cannot exclude similarities with either European or African populations for the trait. However, the lack of expression in Gough's Cave of many other archaic traits found by Irish (1993, 1998) in the sub-Saharan African Dental Complex (i.e, high frequencies of upper canine mesial accessory ridge, Carabelli's trait M^1, cusp 7 M_1, presence of Y-groove pattern M_2, two-rooted P^3, and lack of congenital absence M^3) suggests that Gough's Cave is dentally unlike the African samples.

Surprisingly, Gough's Cave lacked any expression of Carabelli's trait (0/3), although the trait is often found to occur in high frequencies (80%) among modern British (Goose & Lee 1971). The trait is of little use by itself to differentiate at geographic population levels

Table 4 Results for 20 dental traits for Gough's Cave, seven Early populations, and two Recent populations (no. of individuals = 296-1494), compared with Early World average (based on nine geographic populations (North Asia, Nubia, Southeast Asia, Malaysia, South Asia, Early Eurasia, North Europe, Levant, and North American Paleo-Indian). Data for the Early World Average are taken from personal observations and literature (as cited in Hawkey 1998).

0 = absence of any expression; + = some expression (less than or equal to 50% of the sample); ++ = more than half the sample; L = less than 5% of the Early World Average ; A = within 5% more than or less than the Early World Average; H = more than 5% of the Early World Average. Similarities in trait expression percentage indicated in boldface. Gough's Cave score of "0" is similar to "0" and "L", while "+" is similar to "L" or "A". Scores of "++" would be equal to either "A" or "H".

Trait	Gough's Cave[1]	Early Jomon[2]	Early Baikal[3]	Early South Asia[4]	Early Levant[5]	Early Europe[6]	Recent Europe[7]	Early Nubia[8]	Early North Africa[9]	Recent Khoisan[10]	Early World Average
Wing	0	**A**	**H**	**L**	**0**	**0**	**L**	H	**L**	**A**	17.9%
Shov	0	**A**	H	H	**L**	**A**	**L**	H	**A**	**H**	28.2%
DbShov	0	**L**	H	**L**	**L**	**A**	**L**	**0**	**L**	**0**	19.5%
IG	0	H	H	H	**L**	**0**	—	**L**	**H**	**L**	27.7%
TD	+	**L**	**L**	**L**	H	**H**	H	**L**	**L**	**A**	48.0%
MAR	0	**L**	**A**	**0**	H	**A**	**0**	H	**A**	**H**	7.7%
Hypo	++	**A**	**H**	**H**	**H**	**A**	L	**A**	**H**	L	88.7%
UMC5	0	**A**	—	**A**	**L**	**L**	**L**	**A**	**A**	**A**	26.1%
Para	0	**A**	H	**A**	**A**	**0**	**A**	**0**	**A**	**A**	3.4%
Cara	0	**L**	**A**	**A**	**L**	**L**	H	H	H	H	28.3%
PRCA	+	**A**	**A**	**L**	**H**	—	—	—	**L**	**H**	16.3%
EnExt	0	**A**	**A**	**0**	**0**	**0**	**L**	H	**L**	**0**	14.4%
1RUP1	++	**H**	**H**	—	L	—	L	L	L	**H**	56.3%
PLC#	0	**A**	**A**	**L**	**A**	**H**	**L**	H	**H**	**A**	67.4%
Y	0	**H**	**L**	**H**	**H**	**L**	**L**	H	**H**	**H**	20.9%
6CLM1	0	H	H	**L**	**L**	**L**	**L**	**A**	**L**	**L**	26.0%
4CLM2	++	L	L	**H**	L	**H**	**H**	0	L	L	71.4%
Proto	+	**L**	H	**L**	**L**	**H**	**L**	H	**A**	**A**	22.6%
C7	0	**A**	H	**A**	**A**	**L**	**H**	**A**	**A**	**H**	6.8%
Tomes	+	**L**	**A**	—	**A**	**L**	**L**	H	**L**	A	21.3%
Totals		16/20 **80.0%**	10/19 **52.6%**	15/18 **83.3%**	14/20 **70.0%**	15/18 **83.3%**	13/18 **72.2%**	8/19 **42.1%**	14/20 **70.0%**	12/20 **60.0%**	

[1] Present study
[2] Turner 1987
[3] Turner 1987
[4] Hawkey 1977; Lukacs 1986
[5] Lipschultz 1996
[6] Alexandersen 1963; Beillard, cited in Brabant 1976; Brabant 1971, 1976; Brabant & Ketelbant 1975; Brabant et al. 1961; deTerra 1905; Haeussler 1996; Hellman 1928; Turner & Benjamin 1989; Turner & Hawkey 1991, 1998
[7] Axelsson & Kirveskari 1977; Brabant & Ketelbant 1975; Goose & Lee 1971; Guigui 1974; Hjelmman 1928; Kaczmarek 1981; Kirveskari 1974; Lavelle et al. 1970; Morris 1975; Morris et al. 1978; Pedersen 1949; Sauter & Moeschler 1960; Schwerz 1917; Scott 1973, 1977; Selmer-Olsen 1949; Turner & Benjamin 1989; Turner & Hawkey 1991, 1998; Zubov & Kaldiva 1979
[8] Irish 1993
[9] Irish 2000
[10] Irish 1993

(Turner & Hawkey 1998) however, with the range in modern North Europeans (29–80%) quite variable in terms of trait presence. Although presence of Carabelli's trait averages 43% in modern North Europe, the same percentage is found in North American Indians, and is often even higher (53%) in modern sub-Saharan and West Africans.

Thus, by the Late Pleistocene/Early Holocene, Gough's Cave shows the strongest dental similarity with Noth Europe, South/Southwest Asia and North Africa. They appear to be dentally unlike either East Africa (Nubia), South Africa (modern Khoisan), or North Asia (Baikal).

Metrics: While the amount of environmental influence on tooth size is debatable (Goose 1963; Hillson 1986; Kieser 1990; Lukacs 1985; Scott & Turner 1988, 1999), crown shape appears to be another reliable way to assess population affinity (Corruccini 1973). When compared with TCA results for earlier samples from Europe (Table 5) Gough's Cave is approximately 13% smaller than European Neanderthal dentition (based on I1-M3), but only 3% smaller than Late Upper Paleolithic Europeans. Gough's Cave is closest to other European Mesolithic populations, and have teeth 4% larger than Neolithic Europeans, and 10% larger than modern Europeans. The latter result supports the post-Pleistocene trend towards dental reduction, most likely due to relaxed selection for large tooth/body size (Brace & Mahler 1971; Wolpoff 1971).

Table 5 Temporal comparisons of Total Crown Area (TCA) for early to recent Europe. Gough's Cave value is calculated with M3 data to compare with published information. (Source for non-Gough's Cave sample: Brace *et al* 1991).

TCA (mm^2)I1-M3	Period
1415	Neanderthal
1267	Late Upper Paleolithic Europe
1237	Mesolithic Europe
1244	**Gough's Cave (Late Upper Paleolithic-Mesolithic)**
1196	Neolithic Europe
1127	Modern Europe

Table 6 Total Crown Area (TCA) for Gough's Cave (Late Pleistocene/Early Holocene) compared to early and modern populations. The TCA is calculated without M3 data. Samples that contain only males are indicated as M; pooled data for both sexes are designated as M&F.

TCA (mm^2) I1-M2	Area/Site	Sex	Source
1158	Nubia (Mesolithic East Africa)	M	Calcagno 1986
1103	Mahadaha (Mesolithic India)	M&F	Lukacs & Hemphill 1992
1054	Natufian (Epi-Paleolithic Levant)	M&F	Dahlberg 1960
1037	Mehrgarh (Neolithic Pakistan)	M&F	Lukacs 1985
1034	**Gough's Cave (Late Paleolithic-Mesolithic)**	**M&F**	**Present study**
981	Jomon (Early Japan)	M	Brace & Nagai 1982
981	Anglo-Saxon (Early Britain)	M	Lavelle 1968
966	Britain (Recent)	M	Lavelle 1968
910	Khoisan (Recent South Africa)	M	Haeussler *et al* 1989; van Reenan 1982

In order to compare Gough's Cave with published data for Holocene populations, the results are based on measurements for I1-M2 (Table 6). According to Brace (1980), differences of more than 100 mm^2 summed TCA are significant statistically, while differences of more than 50 mm^2 are probably significant. The TCA values for Gough's Cave are closest with the incipient agriculturalists of Neolithic Mehrgarh (Pakistan) with only 3 mm^2 difference, and Levant Natufians (20 mm^2). Four other populations were within 100 mm^2 difference: the Anglo-Saxons (53 mm^2), Jomon (53 mm^2), Recent Britain (68 mm^2) and Mesolithic Mahadaha in Indo-Gangetic India (69 mm^2). Gough's Cave TCA values are unlike those of Late Pleistocene Nubia (124 mm^2) and modern sub-Saharan Khoisan-speakers (124 mm^2).

A similar pattern appears in the Penrose *size* component (Table 7), with Levant Natufians (0.02), Mehrgarh (0.04) and Mahadaha (0.05) most similar to Gough's Cave. The component for Anglo-Saxon (0.33), Jomon (0.39), and Nubia (0.59) show less similarity. Recent Britain (0.97) and Khoisan (1.14) are least like Gough's Cave in occlusal crown size. The two groups that show closest similarity in Penrose *shape* are the Natufians (0.87) and Mehrgarh (0.97), mirroring the size component results. However, the remaining sample indicates moderate similarity (Jomon = 1.07, Nubia = 1.10, Mahadaha = 1.24, Khoisan = 1.34) with Anglo-Saxon (2.39) and Recent Britain (4.22) the most dissimilar to Gough's Cave in shape component.

The differences between the size and shape results may be due to several factors. The most likely explanation is that the size component results reflect sexual dimorphism in tooth size. Gough's Cave, Natufians, Mehrgarh and Mahadaha (the most similar in size component results) are all from pooled samples of males and females. All other data are from males only.

Table 7 Results of Penrose statistic (Shape/Size) for Gough's Cave sample (Late Pleistocene/Early Holocene) compared with eight other populations.

	Gough's Cave sample		
	Size component	Shape component	Combined statistic
Natufian (M&F)	0.02	0.87	0.89
Mehrgarh (M&F)	0.04	0.97	1.01
Mahadaha (M&F)	0.05	1.24	1.29
Anglo-Saxon (M)	0.33	2.39	2.72
Jomon (M)	0.39	1.07	1.46
Nubia (M)	0.59	1.10	1.69
Recent British (M)	0.97	4.22	5.19
Khoisan (M)	1.14	1.34	2.48

Another possibility is that the TCA and Penrose size statistic, both of which include anterior and posterior teeth, may reflect apportionment differences within populations (Harris & Rathbun 1991). Size differences between incisor/canine and premolar/molar fields within individuals may explain why Recent Britain appears so dissimilar to Gough's Cave in size component, yet so similar in TCA value. Incisor breadth ratio (Table 8) shows that Recent Britain has the most reduced lateral incisors (IB = 0.72) when compared to Gough's Cave (IB = 0.83), yet the molar crown area for M1M2 (Table 9) indicates the molars are similar in size for both groups.

When both metric and morphology differences are compared (Table 10) the data reveal the following consistent patterns:

1. Gough's Cave is most like early populations of South/Southwest Asia, including Pakistan (Mehrgarh) and the Levant (Natufians) in TCA and Penrose size/shape components.
2. Gough's Cave is also similar to other early North Europe populations (in TCA and DAS), although published data for North Europe were unavailable for Penrose size/shape analysis.
3. Both metric and morphology results suggest that Late Pleistocene East Africa (Nubia) and sub-Saharan Africans (modern Khoisan) are most dissimilar to Gough's Cave. The DAS morphological data for Late Pleistocene North Africans (Iberomaurusian) suggest a much closer dental similarity to Gough's Cave than other African regions.
4. Differences within the British Isles suggest Gough's Cave is unlike Anglo-Saxon (53 mm^2 difference) and Recent Britain (68 mm^2 difference) in TCA I1-M2 value, but more similar with Late Pleistocene North Europe (23 mm^2 difference, for available TCA I1-M3 data). Both size and shape components indicate Gough's Cave is dissimilar to Anglo-Saxon, and even less similar to Recent Britain. The DAS data, however, suggest close morphological similarities between Gough's Cave and early North Europe. The discrepancies may reflect temporal fluctuations in environment/subsistence, with the metric data more sensitive than morphology to these variables. In addition, sexual dimorphism and apportionment of tooth size may also have an effect.

Pathology/occlusal attrition/crown chipping: Lack of carious teeth, periodontal pathology and low instance of enamel defects in Gough's Cave is well within the range of other hunter/gatherer populations (Cook & Buikstra 1979; Leigh 1925; Turner 1979). The one individual with less than 2 mm of root exposure between CEJ and the alveolar border is not indicative of periodontal disease, but is most likely the result of further root eruption to compensate for attrition, and correlated with age (Clarke & Hirsch 1991). Similarly, there is one young adult with antemortem tooth loss, suggesting an occupationally related cause rather than due to carious activity or periodontal disease.

Table 8 Incisor Breadth ratio (IB) of upper central and lateral incisors compared with early and recent populations.

IB	Area/Site	Sex	Source
0.83	**Gough's Cave (Late Paleolithic-Mesolithic)**	M&F	**Present study**
0.83	Jomon (Early Japan)	M	Brace & Nagai 1982
0.80	Mehrgarh (Neolithic Pakistan)	M&F	Lukacs 1985
0.80	Mahadaha (Mesolithic India)	M&F	Lukacs & Hemphill 1992
0.80	Nubia (Mesolithic East Africa)	M	Calcagno 1986
0.78	Khoisan (Recent South Africa)	M	Haeussler *et al* 1989; van Reenan 1982
0.78	Anglo-Saxon (Early Britain)	M	Lavelle 1968
0.75	Natufian (Epi-Paleolithic Levant)	M&F	Dahlberg 1960
0.72	Britain (Recent)	M	Lavelle 1972

Table 9 Molar Crown Area calculated for upper and lower M1 and M2 (M1-M2CA) and compared to early and recent populations.

M1-M2CA(mm^2)	Area/Site	Sex	Source
536	Nubia (Mesolithic East Africa)	M	Calcagno 1986
503	Mahadaha (Mesolithic India)	M&F	Lukacs & Hemphill 1992
503	Natufian (Epi-Paleolithic Levant)	M&F	Dahlberg 1960
486	Mehrgarh (Neolithic Pakistan)	M&F	Lukacs & Hemphill 1991
486	**Gough's Cave (Late Paleolithic-Mesolithic)**	**M&F**	**Present study**
485	Britain (Recent)	M	Lavelle 1968
465	Jomon (Early Japan)	M	Brace & Nagai 1982
448	Anglo-Saxon (Early Britain)	M	Lavelle 1968
428	Khoisan (Recent South Africa)	M	Haeussler *et al* 1989; van Reenan 1982

Table 10 Comparisons of Gough's Cave metric and morphological data for TCA absolute mean difference (TCAD), Penrose Size (PEN SIZE), Penrose Shape (PEN SHAPE), and Morphology (DAS) ranked in terms of most similar to least similar.

Site/Area	TCAD	Site/Area	PEN SIZE	Site/Area	PEN SHAPE	Site/Area	DAS %
Mehrgarh	3	Natufian	0.02	Natufian	0.87	Early Europe	83.3
Natufian	20	Mehrgarh	0.04	Mehrgarh	0.97	Early S. Asia	83.3
Early Europe	23	Mahadaha	0.05	Jomon	1.07	Early Jomon	80.0
Jomon	53	Anglo-Saxon	0.33	Nubia	1.10	Recent Europe	72.2
Anglo-Saxon	53	Jomon	0.39	Mahadaha	1.24	Early Natufian	70.0
Recent Britain	68	Nubia	0.59	Khoisan	1.34	Early N. Africa	70.0
Mahadaha	69	Recent Britain	0.97	Anglo-Saxon	2.39	Recent S. Africa	60.0
Nubia	124	Khoisan	1.14	Recent Britain	4.22	Early Baikal	52.6
Khoisan	124					Early Nubia	42.1

Although an increase in the presence of calculus has been observed with the advent of Neolithic culture (Hildebolt & Molnar 1991), calculus deposits on the teeth are also found in populations with hunter-gatherer or mixed economies, and may actually be under-reported in archaeological specimens due to preservation or postmorten damage (Brothwell 1981). Evidence of phytoliths within the calculus deposits of Gough's Cave teeth has been recovered by K. Dobney of University of Bradford (reported in, Currant *et al* 1989). While the presence of phytoliths can introduce a somewhat abrasive element into the diet, the teeth of the Gough's Cave sample are not excessively worn. However, a hunter-gatherer subsistence strategy also includes a reliance on meat, an element that is not necessarily abrasive to the dentition (Hillson 1986). Thus, the presence of crown microtrauma in Gough's Cave may be at least partially related to subsistence, especially when grit and bone may be present in the diet (Turner & Cadien 1969).

Although caution should be used in a macroscopic analysis of enamel disturbances (Hillson & Brand 1997), it has been suggested that hunter/gatherers tend to be less severely affected by enamel hypoplasias (Cook & Buikstra 1979; Lukacs *et al* 1982), with the average age of onset between four to five years of age (Schulz & McHenry 1975). But the low instance of enamel hypoplasia in the Gough's Cave sample may not reflect a lack of nutritional stress, because there can be a variety of underlying causes (Goodman & Rose 1991). The Mesolithic site of Mahadaha, for example, exhibits a high frequency (64%) of enamel defects, although the population appears to be free of nutritional stress markers in the osseous remains (Lovell 1992). Some authors have suggested that the amount of stress seen in a population may be reflected in greater dental asymmetry (Bailit *et al* 1970), or even by significant tooth size variation within age groups (Guargliardo 1982), neither of which are especially apparent in the limited number of individuals from Gough's Cave.

Other features: An absence of evidence for either enamel cleaning striations or interproximal grooves, coupled with a lack of caries, periodontal pathology and only slight degree of calculus, suggest that the people of Gough's Cave did not need to practice a rigorous form of dental hygiene. Early teeth cleaning practices, however, have been noted in the Middle East, Asia, Africa, and North American Indians, who often utilized the frayed end of twigs to clean the teeth (Hawkey *et al* n.d.). Similarly there is even earlier evidence for interproximal grooves between the teeth, usually attributed to use of a 'toothpick' to remove irritating substances. These grooves have been reported for a variety of groups in Europe, dating from the Late

Paleolithic to the Bronze Age (Alexandersen 1978; Bennike 1985; Formicola 1988; Frayer & Russell 1987; Turner 1988), were noted in the Neolithic remains from Mehrgarh (Lukacs & Pastor 1988), and possibly in South African Late Pleistocene sites (Grine & Henshilwood 2002; Grine *et al* 2000).

The earliest evidence of intentional modification of the anterior teeth is the ablation seen at Minatogawa, dating to circa 18,000 years BP (Hanihara & Ueda 1982). In addition, intentional filing of the labial surface of incisors has been reported in early Holocene in South Asia (Kennedy *et al* 1981), and the practice of dental modification commonly occurs in Africa, the Americas, South Asia, Japan, Southeast Asia, Australia and Melanesia (Hawkey n.d *b*; Milner & Larsen 1991). There are no instances of intentional dental modification (ablation, filing, or inlay) in the Gough's Cave sample, a fact that is supported by ethnographic reports that suggest the later populations of Europe and the Middle East abhorred the loss of the anterior teeth (Guerini 1977; Kanner 1928).

There are only a few cases of possible dental modification in early Britain (Jackson 1915), from two sites ascribed to a Neolithic culture (Dog Holes cave in Lancashire, and Perthi Chwareu caves in North Wales). Jackson's description of the specimens remains unconvincing, however, as examples of intentional dental modification. There is an abnormal amount of wear on all four specimens, particularly those with loss of central incisors, and the loss may due to excessive attrition leading to exposure of the pulp chamber and premature exfoliation of the teeth. Interestingly, two of Jackson's specimens display antemortem loss of lower premolars; one individual from Gough's Cave has antemortem loss of LP^4. Because the loss seen in both Gough's Cave and two of Jackson's specimens are not anterior teeth, it is unlikely to be intentional dental modification. The antemortem tooth loss seen in Gough's Cave, in particular, is more likely due to activity-induced traumatic injury, a situation observed in populations as ecologically disparate as the Arctic (Merbs 1983) and Pakistan (Lukacs & Hemphill 1990).

CONCLUSIONS

Although the dental remains from Gough's Cave are from a numerically limited series, several trends are suggested, with the underlying assumption that dentition from these individuals accurately represent the Late Pleistocene/Early Holocene populations of the British Isles. It is cautioned , however, that the results are tentative and may reflect statistical fluctuations due to small sample size.

1) *Morphology*: The individuals from Gough's Cave have a simplified dental pattern, similar to the dentition of other Late Pleistocene/Early Holocene populations of North Europe, the Levant, and North Africa. They have similarities with two other groups, also with a simplified pattern: South Asia (Indodont pattern) and the Jomon (Sundadont pattern). They are dentally unlike populations of modern sub-Saharan Africa, Mesolithic Nubia, or the more complex Sinodont dentition of Lake Baikal. Gough's Cave lacks expression of any of the archaic traits, with the exception of P_3 Tomes' root.

2) *Metrics*: Gough's Cave dentition is more similar in crown size to other Mesolithic European populations, exhibiting a significant reduction in tooth size from European Neanderthals, consistent with the post-Pleistocene trend in dental reduction. Among the Late Pleistocene/Early Holocene comparative samples, Gough's Cave is most similar in dental crown size to early populations from the Levant, South/Southwest Asia, and North Europe, but unlike both early East Africa (Nubia) and modern sub-Saharan Africa (Khoisan). When both morphology and metric differences are compared, a similar pattern tends to occur, although no published metric data are available for North Africa (Iberomaurusian). There are temporal differences within the British Isles: Gough's Cave appears most similar to the North Europe sample dating to the approximately the same time period. Gough's Cave is less similar to Anglo-Saxon, with the Recent Britain sample even more dissimilar. A trend towards lateral incisor reduction occurs in later British populations, with Molar Crown Area remaining approximately the same as Gough's Cave. This finding may have some effect on the odontometric analysis, reflecting apportionment changes between the incisor/canine and premolar/molar fields with time.

3) *Pathology/occlusal attrition/crown chipping*: The dental pathology profile is consistent with that of a hunter-gatherer lifeway, with absence of caries, no periodontal disease, and low frequency of enamel hypoplasia. The diet was probably not particularly abrasive, because the teeth show evidence of a gradual progression of attrition with age, rather than evidence of excessive wear during adolescence. An almost complete absence of enamel hypoplasia, along with little dental size asymmetry suggest a relatively healthy population. This low incidence of enamel hypoplasia may indicate a lack of nutritional stress, similar to that noted by Kennedy *et al* (1986), for the Mesolithic site of Sarai Nahar Rai in India, where hunter/gatherer subsistence strategy and ecological conditions may well have provided an abundance of food resources. Given the absence of caries in these remains, it is probable that the only instance of antemortem tooth loss in one individual may be occupationally related, especially considering the excessive enamel microtrauma found on the anterior teeth.

4) *Other features*: Similar to other European populations, there is no convincing evidence of intentional dental modification. Although there have been some reports of interproximal 'toothpick' grooves and cleaning striations among European Neanderthal populations, the lack of these features in Gough's Cave individuals may be related to the low instance of caries, and the presence of only slight-moderate degree of supragingival calculus.

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